EARTH GRIDDING

VISIBLE/INFRARED IMAGER/RADIOMETER SUITE ALGORITHM THEORETICAL BASIS DOCUMENT

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GLOSSARY OF ACRONYMS

ATBD	Algorithm Theoretical Basis Document
ARP	Application Related Product
BRDF	Bi-directional Reflectance Distribution Function
CDR	Critical Design Review
CMIS	Conical-Scanning Microwave Imager/Sounder
CrIS	Cross-track Infrared Sounder
DEM	Digital Elevation Model
DPA	Data Processing Architecture
DPSA	Dark Pixel Sub Algorithm (for Surface Albedo)
DoD	Department of Defense
ECS	EOSDIS Core System
EDR	Environmental Data Record
EOSDIS	Earth Observing System Data and Information System
GCTP	General Cartographic Transformation Package
GDSR	Gridded Daily Surface Reflectance
GMBT	Gridded Monthly Brightness Temperature
GMSR	Gridded Monthly Surface Reflectance
GMVI	Gridded Monthly Vegetation Index
GSA	Gridded Surface Albedo
GWSR	Gridded Weekly Surface Reflectance
HDF-EOS	Hierarchical Data Format-Earth Observing System
HSR	Horizontal Spatial Resolution
IP	Intermediate Product
IPO	Integrated Program Office
MNSR	Monthly Non-snow Surface Reflectance
MODIS	Moderate-Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
NCEP	National Centers for Environmental Predication
NDVI	Normalized Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NPP	Net Primary Productivity
OMPS	Ozone Mapping and Profiler Suite
PSN	Net Photosynthesis
RDR	Raw Data Record
SBRS	Santa Barbara Remote Sensing
SDR	Sensor Data Record
SNR	Signal-to-Noise Ratio
SRD	Sensor Requirements Document

TSPR	Total System Performance Responsibility
TOA	Top of Atmosphere
USGS	United States Geological Survey
VIIRS	Visible/Infrared Imager/Radiometer Suite
VVI	VIIRS Vegetation Index
WVI	Weekly Vegetation Index

ABSTRACT

Most of the Visible/Infrared Imager/Radiometer Suite (VIIRS) Environmental Data Record (EDR) algorithms will require as input one or more types of auxiliary data. In most cases the auxiliary data are obtained from sources that are independent of the National Polar-orbiting Operational Environmental Satellite System (NPOESS). In some cases, recent VIIRS retrievals are required, and co-located Conical-Scanning Microwave Imager/Sounder (CMIS), Cross-track Infrared Sounder (CrIS), and Ozone Mapping and Profiler Suite (OMPS) data are desirable. These data will generally not be reported at the current VIIRS pixel locations but rather will be reported at some fixed Earth grid locations or some instrument specific pixel locations in the VIIRS pixel neighborhood.

This document describes the mapping and gridding that will be performed within the VIIRS Data Processing Architecture (DPA) in support of the EDR generation algorithms. The approach presented provides a computational efficient solution that will result in all information needed for the EDR algorithms to match auxiliary data to the VIIRS observations.

1.0 INTRODUCTION

1.1 PURPOSE

This Algorithm Theoretical Basis Document (ATBD) discusses the approaches to re-grid auxiliary data and to grid VIIRS Sensor Data Record (SDR), Intermediate Product (IP), and Environmental Data Record (EDR) data. This document describes the required inputs, practical considerations for post-launch implementation, the assumptions and limitations associated with these approaches, and the description of the re-gridding and gridding techniques.

Throughout this document are references to other Raytheon Santa Barbara Remote Sensing (SBRS) documents. These references use the SBRS document number set in italic font and enclosed in brackets (e.g. *[Y12345]*). When a document is first referenced its complete title is given along with the document number.

This ATBD is part of the VIIRS Algorithm Subsystem's documentation hierarchy as called for in the VIIRS Software Development Plan *[Y2388]*. As shown in Figure 1 the Algorithm Subsystem Specification *[PS154640-102]* is the controlling document for this ATBD. The software architecture for implementing the re-gridding and gridding algorithms will not be provided and is considered a Total System Performance Responsibility (TSPR) contractor activity.

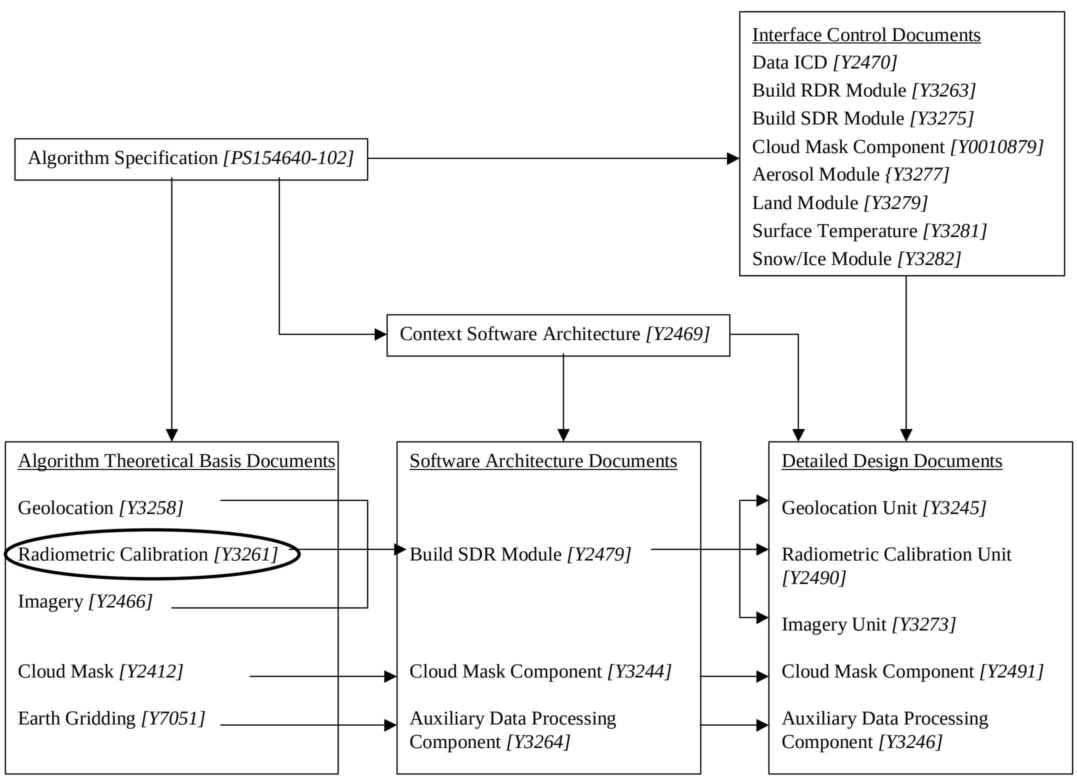

Figure 1. Hierarchy of VIIRS documents that relate to the design of the gridding software (this ATBD is circled)

1.2 SCOPE

This document covers the algorithm theoretical basis for a possible operational approach to re-gridding and gridding. There are no gridded EDR deliverables in the VIIRS Sensor Requirements Document (SRD) (IPO, 2000). Therefore discussion will be limited to the gridding needed to support the generation of EDR swath products including the production of gridded IPs. The algorithms discussed herein could be adapted to the production of gridded EDR products if such a requirement develops at a future date.

This section describes the purpose and scope of this document. Section 2 provides a brief overview of the objectives of the re-gridding and gridding and a candidate strategy for an operational approach. Section 3 contains the essence of this document. Consideration is given to the overall structure, the required inputs, a description of the products, and practical implementation issues. Section 4 contains a listing of reference documents that are cited throughout this document.

1.3 DEFINITIONS

The following definitions are relevant to this ATBD:

<u>Auxiliary Data</u>

Those non-VIIRS data required by the EDR algorithms as identified in the VIIRS Interface Control Document *[Y2470]* are the auxiliary data.

<u>Gridding</u>

Gridding is the process of accumulating VIIRS pixel data into grid cells on an Earth model then combining these data through data selection, weighting, interpolation, and averaging to a single value per grid cell that is representative of the retrieval at that location or area during a specific time period.

<u>Re-gridding</u>

Re-gridding is the process of referencing auxiliary data to the VIIRS pixel data. Auxiliary data may be representative of locations or areas on a fixed grid or may be representative of points on the surface of the Earth that are not uniformly distributed. Typically the distribution of each auxiliary data type will be much coarser than the spacing between the centers of VIIRS pixels, except in the case of previously generated VIIRS Intermediate Products (IPs).

1.4 REVISIONS

Version 5 is the second working version of this document and is a VIIRS Critical Design Review (CDR) deliverable. It is dated February 2002.

Version 4 was the first version of this ATBD. Its version number was chosen to match the delivery of the previously existing VIIRS EDR ATBDs, which had undergone three previous version releases.

2.0 EXPERIMENT OVERVIEW

2.1 OBJECTIVES OF EARTH GRIDDING

Each EDR (except Imagery) requires some type of re-gridded and/or gridded data input for operational processing. Because of the 20 minute per orbit processing time constraint placed on the VIIRS algorithm subsystem the re-gridding and gridding schemes must be capable of co-locating the needed data to the VIIRS pixel locations in a highly efficient way.

2.2 INSTRUMENT CHARACTERISTICS

A VIIRS will be carried aboard each platform of the National Polar-orbiting Operational Environmental Satellite System (NPOESS). NPOESS is a joint mission between the Department of Defense (DoD), the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA). The VIIRS is a single visible/infrared sensor capable of satisfying the needs of all three communities, as well as the general research community. As such, the VIIRS will have three key attributes: high spatial resolution with controlled growth off nadir, low production and operational cost, and a large number of spectral bands to satisfy the requirements for generating accurate operational and scientific products. The nominal altitude for an NPOESS satellite will be 833 km. The VIIRS scan will extend to 56 degrees on either side of nadir.

The VIIRS SRD places explicit requirements on spatial resolution for the Imagery EDR. Specifically, the horizontal spatial resolution (HSR) of bands used to meet threshold Imagery EDR requirements must be no greater than 400 m at nadir and 800 m at the edge of the scan. This led to the development of a unique scanning approach which optimizes both spatial resolution and signal to noise ratio (SNR) across the scan. The concept is summarized in Figure 2 for the imagery bands; the nested lower resolution radiometric bands follow the same approach at exactly twice the size. The VIIRS detectors are rectangular, with the smaller dimension projecting along the scan. At nadir, three detector footprints are aggregated to form a single VIIRS “pixel.” Moving along the scan away from nadir, the detector footprints become larger both along track and along scan, due to geometric effects and the curvature of the Earth. The effects are much larger along scan. At approximately 32 degrees in scan angle, the aggregation scheme is changed from 3x1 to 2x1. A similar switch from 2x1 to 1x1 aggregation occurs at 48 degrees. The VIIRS scan consequently exhibits a pixel growth factor of only 2 both along track and along scan, compared with a growth factor of 6 along scan which would be realized without the use of the aggregation scheme.

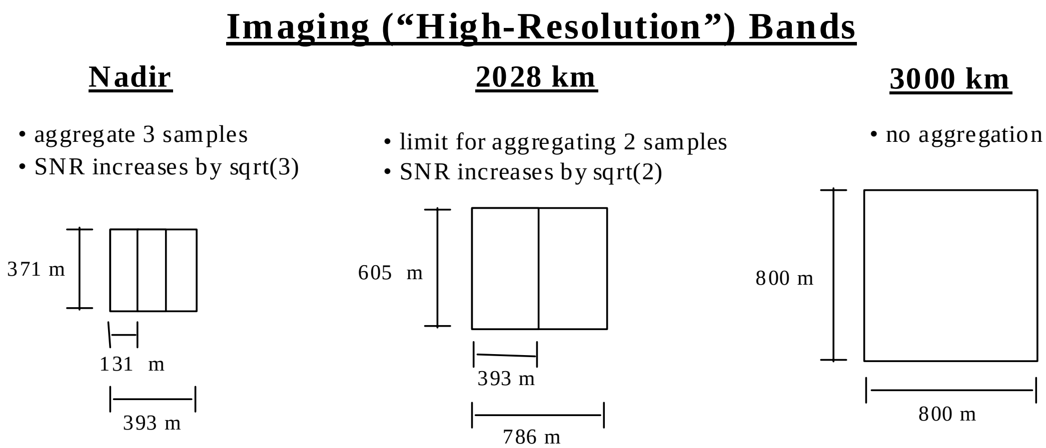

Figure 2. VIIRS detector footprint aggregation scheme for building "pixels." Dimensions are approximate; please see the VIIRS Sensor Specification for the most current values.

2.3 EARTH GRIDDING STRATEGY

Earth gridding includes two distinct processes: gridding and re-gridding.

Gridding is the process of accumulating VIIRS pixel data into grid cells on an Earth model then combining these data through data selection, weighting, interpolation, and averaging to a single value per grid cell that is representative of the retrieval at that location or area during a specific time period.

Re-gridding is a process of referencing auxiliary data and previously gridded IPs to the VIIRS pixel data. Auxiliary data may be representative of locations or areas on a fixed grid or may be representative of points on the surface of the Earth that are not uniformly distributed. In general the distribution of each auxiliary data type will be much coarser than the spacing between the centers of VIIRS pixels. Exceptions are the digital elevation model (DEM), which will be processed by the Geolocation unit (see the VIIRS Geolocation ATBD *[Y3258]*). Therefore this ATBD will be limited to the re-gridding of coarser resolution auxiliary data.

There is some commonality in these processes, however the position in the process sequence differs. Commonalities include the Earth model on which each will be based and the technique for mapping data to this model. Gridding of VIIRS EDRs and IPs is a post-processing activity, outside of the 20-minute operational timeline. Re-gridding of numerical weather analyses, previously generated gridded VIIRS products, and data from other NPOESS sensors or non-NPOESS sources is a pre-processing activity, included in the 20-minute timeline.

3.0 ALGORITHM DESCRIPTION

3.1 PROCESSING OUTLINE

Re-gridding and gridding will be performed at various times relative to the operational processing. Some will be done as pre-processing steps prior to receipt of mission data, some will be performed during the processing of mission data, and some will be performed during post-EDR processing.

In general auxiliary data and required gridded IPs re-gridding will be performed during the processing of mission data. Auxiliary data will be interpolated to pixel locations and previously gridded IPs will be either interpolated or provide the nearest neighbor to pixel locations.

The DEM will be processed in the main production processing as part of geolocation. The DEM processing will yield geoid and terrain height. A land-water-coastline indicator will be derived from the auxiliary land-water mask as part of the generation of the Cloud Mask IP. Each of these will be determined at the VIIRS pixel locations and stored in each SDR file.

Re-gridding will provide the information needed for EDR algorithms to efficiently access auxiliary data that is co-located with VIIRS pixels. Re-gridding will not perform any selection or interpolation among Auxiliary data that may be available for different times. For example if an EDR algorithm is to process data observed at 0900Z the algorithm may require that there be an interpolation between NCEP model predictions at 0600Z and 1200Z. This interpolation will have to made within the EDR module. The re-gridding algorithm will provide the pointers that the EDR module will need to access the co-located data in both the 0600Z file and the 1200Z file that would be used in this interpolation.

Gridding of VIIRS SDRs, IPs, and EDRs will be a post-processing activity so as not to interfere with operational EDR production. In each case these gridded VIIRS data will be available to subsequent processing as the latest available data (i.e. current gridded data will not be used to process current data).

3.2 ALGORITHM INPUT

3.2.1 VIIRS Data

The following VIIRS data will be input to the VIIRS gridding algorithms:

- Calibrated Top of Atmosphere (TOA) Brightness Temperature SDR
- Ice Age EDR
- Ice Concentration Application related Product (ARP)
- Surface Reflectance IP
- Surface Types IP
- Snow Cover/Depth EDR

3.2.2 Non-VIIRS Data

Auxiliary data from a variety of sources and in a variety of formats will be re-gridded. These auxiliary data are identified as part of the algorithm subsystem specification *[PS154640-102]* and are further defined in the *[Y2470]*. Table 1 summarizes the sources and types of auxiliary data. This table is subject to change as the EDR algorithm requirements mature.

Table 1. Auxiliary Data

Source	Type
ASTER	Spectral Library DEM ?
CMIS	Calibrated Microwave Brightness Temperature SDR (current) Cloud Liquid Water (latest) Cloud Ice Water Path (latest) Ice Age Sea Surface Winds (current ?) Surface Air Temperature (average over previous 12 hours)
CrIS	Surface Air Temperature (average over previous 12 hours) - Alternate Total Column Ozone (latest) – Fallback
Defense Mapping Agency (DMA)	Digital Bathymetric Database (non-coastal areas) Digital Elevation Model Land/Water Mask (vector shoreline)
EROS Data Center (EDC)	Geolocation Control Points (Landsat-7) Land/Water Mask
Fleet Numerical Meteorological Operational Center (FNMOC) or European Center for Medium Range Weather Forecasting (ECMWF)	Moisture Profile - Fallback Precipitable Water – Fallback Pressure Profile – Fallback Sea Surface Winds – Fallback Surface Air Temperature – Fallback Surface Pressure – Fallback Surface Temperature – Fallback Temperature Profile - Fallback
Goddard Institute for Space Science (GISS)	Aerosol Climatology (ocean)
MODIS	Aerosol Climatology (land) Geolocation Control Points Surface Types (at launch)
National Center for Environmental Prediction (NCEP) (analysis and model predictions)	Moisture Profile Precipitable Water Pressure Profile Ozone Concentration Sea Surface Winds Surface Air Temperature Surface Humidity Surface Pressure Surface Temperature Temperature Profile
National Data Buoy Center (NDBC)	Sea Surface Temperature (buoy locations)
National Ocean Service (NOS)	Digital Bathymetric Database (U.S. coastal waters)
National Weather Service (NWS)	Conventional Cloud Cover Observations (most recent)
OMPS	Total Column Ozone (latest)
Thuiller - SOLSPEC	Extraterrestrial Solar Irradiance

3.3 THEORETICAL DESCRIPTION OF EARTH GRIDDING

3.3.1 Grid Selection

The Integerized Sinusoidal Projection as implemented in the HDF-EOS Library for the Earth Observing System Data and Information System (EOSDIS) Core System (ECS) Project is adopted for the VIIRS global grid. This approach uses the United States Geological Survey (USGS) General Cartographic Transformation Package (GCTP) to define, create, and make use of gridding functions.

3.3.1.1 Considerations

VIIRS pixel size – select a grid size that is close to the spacing between the moderate resolution band pixels. The latitudinal grid size will be approximately 1 km.

Number of cells – select a grid size that will result in a reasonable number of grid cells – consider storage and processing efficiency – convenient aggregation of cells should be considered.

Layout of cells – maintain a simple relationship between latitude and longitude and grid boundaries – avoid grid cells that straddle the Equator or a Pole due to physical (e.g. Coriolis force at Equator) and mathematical considerations.

3.3.1.2 Grid Definition

The VIIRS grid will be defined and created using GCTP.

3.3.2 Grid Cell Identification

Each grid cell will be assigned an integer row and column as determined and maintained by GCTP.

3.3.3 Mapping Auxiliary Data

Auxiliary data, including previously generated VIIRS products, data from other NPOESS sensors, and non-NPOESS data sets, will be processed for each granule. After the receipt of a granule, a subset of the required auxiliary data will be extracted. This subset will cover the same spatial area of the granule. A bi-linear interpolation will be performed for each pixel location within the granule and interpolated values of the selected auxiliary data will be stored using the same indexes that identify pixels.

3.3.4 Auxiliary Data Access in EDR Modules

In general EDR algorithms will have direct access to the auxiliary data that a pixel retrieval needs by using the same indexes that EDR algorithms use to access pixel data.

3.3.5 Generation of Gridded VIIRS SDRs, IPs, and EDRs

3.3.5.1 General Approach

The gridded products will be tables that created and maintained by GCTP capabilities.

For those gridded products that are averages over some time period (daily, weekly, monthly, and quarterly) a new table is created every time a new orbit of data becomes available (here an orbit is defined as all data downlinked at the same time) – at some pre-defined frequency the tables for the specified time period are combined using interpolation and averaging techniques that are product specific to create a new table.

3.3.5.2 Product Specific Algorithms

Details regarding the definition and the rules for data selection, interpolation, and averaging are listed according to gridded product.

Gridded Daily Surface Reflectance IP

The Gridded Daily Surface Reflectance (GDSR) Intermediate Product (IP) is required for the retrieval of the Surface Albedo EDR over dark surfaces, including most vegetation and water. For these surfaces, pixel-level retrievals are based on an extension of the MODIS albedo algorithm, described in great detail in Lucht *et al.* (2000). The modification of this algorithm for VIIRS purposes, hereafter referred to as the Surface Albedo Sub-Algorithm 1 (SASA1) is presented in the VIIRS Surface Albedo ATBD *[Y2398]*.

SASA1 operates on a running window of sixteen days worth of daily surface reflectance data, to allow the inversion of a system of equations yielding the necessary coefficients for producing black sky and white sky albedo estimates. Since a temporal series of surface reflectances is required, the data must be mapped to a common grid. The GDSR will therefore be a three-dimensional array with the structure indicated in Table 2.

Table 2. Gridded Daily Surface Reflectance (GDSR) IP array structure.

Dimension	Elements
Temporal	(Current Day) thru (Current Day – 16)
Global Grid (Spatial)	Grid Cell Row and Column Numbers
Parameter	Reflectance* in VIIRS Bands M1, M2, M3, M4, M5, M6, M8, M10, M11; Solar zenith; View zenith; Relative azimuth

*Grid cells contaminated by cloud, heavy aerosol, etc. contain fill values

At the time of its use, the GDSR IP will consist of data from the sixteen days prior to the current day, plus a partially completed grid for the current day. Once the Surface Reflectance IP has been retrieved and archived for a given granule, it will be resampled via cubic convolution onto the global VIIRS grid for the current day. The solar/viewing geometry must also be resampled and retained in this manner. When the grid for the current day has been completed, the cell values for the GDSR IP will be shifted by one element in the temporal dimension, and the cells corresponding to the current day will once again be blank.

Gridded Weekly Surface Reflectance IP

The Gridded Weekly Surface Reflectance (GWSR) IP is required by the Cloud Effective Particle Size and Cloud Optical Thickness EDRs. For more detail on the algorithms and usage of this product in the Cloud Module, the reader is directed to the VIIRS Surface Reflectance Unit Level Detailed Design *[Y2393]*.

The structure of the GWSR IP is shown in Table 3.

Table 3. Gridded Weekly Surface Reflectance (GWSR) IP array structure.

Dimension	Elements
Temporal	(Composite), (Current Day) thru (Current Day – 8)
Global Grid (Spatial)	Grid Cell Row and Column Numbers
Parameter	Composited, Nadir-adjusted Reflectance* in VIIRS Bands M1, M2, M3, M4, M5, M7, M8, M10, M11

*Grid cells contaminated by cloud, heavy aerosol, etc. contain fill values

The GWSR IP is a running, eight-day, nadir-adjusted composite. Once Surface Reflectance has been retrieved and archived for a given granule, it will be resampled via cubic convolution onto the global VIIRS grid for the current day. This process can be merged with the same process for generating the GDSR IP, so that the GDSR IP itself can be used as the storage mechanism for the non-nadir-adjusted data. Once data are gridded for a given granule, they must be converted to nadir-adjusted values to remove the bi-directional reflectance distribution function (BRDF) signal from the composite. This is done using a BRDF shape associated with the most recent value of the Quarterly Surface Types IP on the VIIRS grid. A simple conversion factor is applied to the resampled surface reflectance data to arrive at the nadir-adjusted value. This nadir-adjusted value is then placed into the current day grid of the GWSR IP. Once the global grid for the current day is complete, the cell values for the GDSR IP will be shifted by one element in the temporal dimension, and the cells corresponding to the current day will once again be blank. Also at this time, the composite grid in the temporal dimension is updated. Each cell in this grid is filled with the mean of all non-cloud cell values from the eight full days of previously computed reflectances. The composite grid is the product used by the Cloud Module.

Gridded Monthly Surface Reflectance IP

The Gridded Monthly Surface Reflectance IP (GMSR) is required for use by the Surface Type EDR, which generates metrics from the IP as inputs to a decision tree classification algorithm. For further details on the Surface Type algorithm, the reader is directed to the VIIRS Surface Type ATBD *[Y2402]*.

The structure of the GMSR IP is shown in Table 4.

Table 4. Gridded Monthly Surface Reflectance (GMSR) IP array structure.

Dimension	Elements
Temporal	(Current Month) thru (Current Month – 2), (Current Week) thru (Current Week – 3)
Global Grid (Spatial)	Grid Cell Row and Column Numbers
Parameter	Composited, Nadir-adjusted Reflectance* in VIIRS Bands M1, M2, M3, M4, M5, M7, M8, M10, M11

*Grid cells contaminated by cloud, heavy aerosol, etc. contain negative fill values
A week is defined to be eight days here

The GMSR IP is a non-running, monthly composite of nadir adjusted reflectances. To minimize storage requirements and computational load, the GMSR IP will be constructed from the GWSR IP. Every eight days—except for the final period within a month, which will consist of between four and seven days—the current composite grid for the GWSR IP will be copied into the appropriate array within the GMSR IP. At the conclusion of each month, the four weekly arrays within the GMSR IP will be averaged into one of the three monthly arrays within the GMSR IP. Every three months, the three monthly arrays in the GMSR IP are used to generate the Quarterly Surface Types IP for Surface Type EDR processing. The processing then starts anew, over-writing all fields within the GMSR IP.

Monthly Non-snow Surface Reflectance IP

The Monthly Non-snow Surface Reflectance IP (MNSR) is required for use by the Snow Cover/Depth EDR, which must characterize the background in a given pixel to estimate the snow fraction using spectral mixture analysis. For further details on the snow fraction algorithm, the reader is directed to the VIIRS Snow Cover ATBD *[Y2401]*.

The structure of the MNSR IP is shown in Table 5.

Table 5. Monthly Non-snow Surface Reflectance (MNSR) IP array structure.

Dimension	Elements
Temporal	(Composite), (Current Day) thru (Current Day – 32)
Global Grid (Spatial)	Grid Cell Row and Column Numbers
Parameter	Composited Spectral Albedo* in VIIRS Bands M1, M2, M3, M4, M5, M7, M8, M10, M11

*Grid cells contaminated by cloud, heavy aerosol, snow, etc. contain fill values
A week is defined to be eight days here

The MNSR IP is a running, monthly composite of narrowband spectral albedo. Once the Surface Reflectance IP has been retrieved and archived for a given granule, it will be resampled via cubic convolution onto the global VIIRS grid for the current day. Pixels categorized as snow by the

Snow Cover/Depth EDR will not be used in the interpolation. Once data are gridded for a given granule, they must be converted to spectral albedo to remove the bi-directional reflectance distribution function (BRDF) signal from the composite. This is done using a BRDF shape associated with the most recent value of the Quarterly Surface Types IP on the VIIRS grid. A simple conversion factor is applied to the resampled surface reflectance data to arrive at the spectral albedo. At the conclusion of each month, the daily arrays within the MNSR IP will be averaged into the composite grid within the MNSR IP. This composite grid is used by the Snow/Cover Depth EDR algorithm.

Gridded Surface Albedo IP

The Gridded Surface Albedo (GSA) IP is required for the retrieval of the Surface Albedo EDR over dark surfaces, including most vegetation and water. For these surfaces, pixel-level retrievals are based on an extension of the MODIS albedo algorithm, described in great detail in Lucht *et al.* (2000). The modification of this algorithm for VIIRS purposes, hereafter referred to as the Dark Pixel Sub-Algorithm (DPSA), is presented in the VIIRS Surface Albedo ATBD *[Y2398]*.

The DPSA operates on a running window of sixteen days worth of daily surface reflectance data, to allow the inversion of a system of equations yielding the necessary coefficients for producing black sky and white sky albedo estimates. Since a temporal series of surface reflectances is required, the data must be mapped to a common grid.

The structure of the GSA IP is shown in Table 6.

Table 6. Gridded Surface Albedo (GSA) IP array structure.

Dimension	Elements
Global Grid (Spatial)	Grid Cell Row and Column Numbers
Parameter	Black Sky Albedo*, White Sky Albedo*

*Grid cells from too few observations contain fill values

The GSA IP is a global VIIRS grid of black sky (direct solar beam only) and white sky (diffuse solar input only) albedos, based on a running set of sixteen days worth of surface reflectance data delivered via the GDSR IP. Each day, the sixteen full days of surface reflectances within the GDSR IP are used to perform an inversion that delivers the black sky and white sky albedo in a given grid cell. These parameters are then ingested by the DPSA for pixel-level retrievals of the Surface Albedo EDR for dark surfaces. For a description of the inversion algorithm and more detail on how the GSA IP interacts with the Surface Albedo EDR, the reader is directed to the VIIRS Surface Albedo ATBD *[Y2398]*.

Gridded Monthly Vegetation Index IP

The Gridded Monthly Vegetation Index (GMVI) IP is required for use by the Surface Type EDR, which generates metrics from the IP as inputs to a decision tree classification algorithm. For further details on the Surface Type algorithm, the reader is directed to the VIIRS Surface Type ATBD *[Y2402]*.

The structure of the GMVI IP is shown in Table 7.

Table 7. Gridded Monthly Vegetation Index (GMVI) IP array structure.

Dimension	Elements
Temporal	(Current Month) thru (Current Month – 2), (Current Week) thru (Current Week – 3)
Global Grid (Spatial)	Grid Cell Row and Column Numbers
Parameter	Composited Normalized Difference Vegetation Index (NDVI)*

*Grid cells contaminated by cloud, heavy aerosol, etc. contain negative fill values
A week is defined to be eight days here

The GMVI IP is a non-running, monthly composite of the Normalized Difference Vegetation Index (NDVI). The physics behind the NDVI are described in the VIIRS Vegetation Index (VVI) ATBD *[Y2400]*. To minimize storage requirements and computational load, the GMVI IP will be produced directly from the GWSR IP. At the conclusion of each week, the red (aggregated I1) and near infrared (aggregated I2) reflectances in the currently computed weekly grid from the GWSR IP will be used to generate the values in the corresponding weekly grid of the GMVI IP. At the conclusion of each month, the four weekly arrays within the GMVI IP will be averaged into one of the three monthly arrays within the GMVI IP. Every three months, the three monthly arrays in the GMVI IP are used to generate the Quarterly Surface Types IP for Surface Type EDR processing. The processing then starts anew, over-writing all fields within the GMVI IP.

Gridded Monthly Brightness Temperature IP

The Gridded Monthly Brightness Temperature (GMBT) IP is required for use by the Surface Type EDR, which generates metrics from the IP as inputs to a decision tree classification algorithm. For further details on the Surface Type algorithm, the reader is directed to the VIIRS Surface Type ATBD *[Y2402]*.

The structure of the GMBT IP is shown in Table 8.

Table 8. Gridded Monthly Brightness Temperature (GMBT) IP array structure.

Dimension	Elements
Temporal	(Current Month) thru (Current Month – 2), (Current Day) thru (First Day of Current Month)
Global Grid (Spatial)	Grid Cell Row and Column Numbers
Parameter	Composited Brightness Temperature* in VIIRS Bands M12, M13, M14, M15, M16

*Grid cells contaminated by cloud, heavy aerosol, etc. contain negative fill values

The GMBT IP is a non-running, monthly composite of brightness temperatures. Once the Calibrated TOA Brightness Temperatures SDR has been retrieved and archived for a given granule, it will be resampled via cubic convolution onto the global VIIRS grid for the current day. At the conclusion of each month, the non-cloud entries within the daily arrays in the GMBT IP will be averaged into one of the three monthly arrays within the GMBT IP. Every three months, the three monthly arrays in the GMBT IP are used to generate the Quarterly Surface Types IP for Surface Type EDR processing. The processing then starts anew, over-writing all fields within the GMBT IP.

Gridded Quarterly Surface Types IP

The generation of the Gridded Quarterly Surface Types IP is described in the VIIRS Surface Type ATBD *[Y2402]*.

VIIRS Vegetation Index (VVI) Tertiary Products

The generation of the VIIRS Vegetation Index (VVI) Tertiary Products, specifically Net Photosynthesis (PSN) and Net Primary Productivity (NPP), will be described in a future version of this document, with the theory detailed in the Vegetation Index ATBD *[Y2400]*.

3.4 PRACTICAL CONSIDERATIONS

3.4.1 Numerical Computation Considerations

Paragraph SRDV3.2.1.5.4-1 of the VIIRS SRD states the following:

> "*The scientific SDR and EDR algorithms delivered by the VIIRS contractor shall be convertible into operational code that is compatible with a 20 minute maximum processing time at either the DoD Centrals or DoD field terminals for the conversion of all pertinent RDRs into all required EDRs for the site or terminal, including those based wholly or in part on data from other sensor suites*."

The algorithms for matching auxiliary data to the VIIRS pixels are straightforward and will have a minimum impact on VIIRS processing resources. The impact of the gridding of VIIRS products will be determined by the definitions an rules that are to be included in Section 3.3.6.2, Product Specific Algorithms.

3.4.2 Programming and Procedural Considerations

It is expected that some of the re-gridding and gridding requirements are not known at the present time or may change in the future. The VIIRS software architecture is flexible enough to accommodate modifications if and when needed.

Details of the software for re-gridding and gridding will be developed by the TSPR contractor.

4.0 REFERENCES

4.1 VIIRS DOCUMENTS

The following VIIRS documents are referenced in this ATBD using their Raytheon SBRS document number in italicized brackets, e.g., *[Y12345]*:

[PS154640-102]	Performance Specification Algorithm Specification for the VIIRS
[Y2388]	VIIRS Software Development Plan
[Y2393]	VIIRS Surface Reflectance Unit Level Detailed Design
[Y2398]	VIIRS Surface Albedo ATBD
[Y2400]	VIIRS Vegetation Index (VVI) ATBD
[Y2401]	VIIRS Snow Cover ATBD
[Y2402]	VIIRS Surface Type ATBD
[Y2469]	VIIRS Context Software Architecture
[Y2470]	VIIRS Data Interface Control Document
[Y2479]	VIIRS Build SDR Module Software Architecture
[Y3258]	VIIRS Geolocation ATBD

4.2 NON-VIIRS DOCUMENTS

The following non-VIIRS documents are references for this ATBD:

HDF-EOS Library User's Guide for the ECS Project, Volume 1: Overview and Examples, November, 2000, 170-TP-600-001.

HDF-EOS Library User's Guide for the ECS Project, Volume 2: Function Reference Guide, November, 2000, 170-TP-601-001.

IPO (2000). Visible/Infrared Imager/Radiometer Suite (VIIRS) Sensor Requirements Document (SRD) for National Polar-Orbiting Operational Environmental Satellite System (NPOESS) spacecraft and sensors, Rev. 2b/c. Prepared by Assoc. Directorate for Acquisition, NPOESS Integrated Program Office, Silver Spring, MD.

Kilpatrick, K.A., G.P. Podesta, and R. Evans. Overview of the NOAA/NASA AVHRR Pathfinder Algorithm for Sea Surface Temperature and Associated Matchup Database, University of Miami.

Lucht, W., C.B. Schaaf, and A.H. Strahler. An Algorithm for the retrieval of albedo from space using semiempirical BRDF models, IEEE Trans. Geosci., Remote Sens., 38, 977-998, 2000.